I. INTRODUCTION

In recent years, concerns about the nutritional adequacy of the diets of certain population subgroups have arisen. The prevalence of obesity and overweight among children, adolescents, and adults has steadily increased over the past four decades (Kuczmarski et al. 1994; Ogden et al. 2002; and Flegal et al. 2002). Despite increases in overweight, food insecurity persists among some subgroups of the population (Nord et al. 2004), and poor diet quality—especially the consumption of high-fat, energy-dense foods—characterize other subgroups (Kant 2000, 2003).

Subgroups of particular concern include adolescent females, older adults, overweight and obese children and adults, individuals living in food-insecure or food–insufficient households, low-income individuals, and individuals targeted by and participating in food and nutrition assistance programs. This report presents detailed analysis findings from a study assessing the diets of these subgroups using the set of dietary reference standards developed by the Institute of Medicine over the past decade. Assessing the diets of these subgroups focuses on the risk of either inadequate or excessive nutrient intakes, as well as other dietary imbalances.

The study uses data from the 1994-1996 and 1998 Continuing Survey of Food Intakes by Individuals to address two primary research questions:

1. What are the characteristics of the distributions of usual nutrient intake for these subgroups?
   - What proportion of the subgroup has inadequate nutrient intake?
   - What proportion of the subgroup is at risk of excessive nutrient intake?
   - How variable are usual nutrient intakes?
2. Does the day-to-day variation (within-person standard deviation) in nutrient intake vary across population subgroups? For example,
   - Do individuals living in food-insecure households have more or less day-to-day variation in nutrient intake than other individuals?

- Do teenage females have greater or smaller day-to-day variation in nutrient intakes relative to other population subgroups?

This report focuses on the first question related to assessing nutrient adequacy, while a separate report examines the second question on the day-to-day variation in nutrient intake. The remainder of this chapter provides some background information on the nutritional adequacy of the diets of specific population subgroups, presents an overview of the study, and describes the report organization and important study considerations. Chapter II describes the outcomes examined and methods used to address the main research questions. Chapter III presents the results from analyses of the usual nutrient intakes. The concluding chapter summarizes the main findings and their implications. An appendix presents tables with usual intake distributions of selected subgroups.

A. BACKGROUND

As knowledge of the relationship between diet and long-term health has increased, so have concerns about the diets of certain population subgroups. Areas of concern include the increasing prevalence of overweight and obesity, the well-established links between chronic disease and dietary practices, and the persistence of hunger and food insecurity. Several groups appear at risk of nutrient deficiencies, dietary imbalances, or excessive intake. In some cases, these assessments were based on inappropriate methods; new assessments using methods proposed by the Institute of Medicine are needed to confirm these concerns.

Adolescent Females. Adolescence is a unique period of growth and development. In addition to maturing physically, teenagers begin to make a greater number of independent decisions about food consumption. Dietary concerns include thinness and overweight, inadequate intakes of micronutrients, meal-skipping, frequent dieting, and eating disorders.

Adolescent females, particularly low-income ones, appear to have low intakes of several micronutrients—iron, calcium, folate, magnesium, phosphorus, zinc, and vitamins A, C, and E (Herbert 1991; Eck and Hackett-Penner 1992; Life Sciences Research Office 1995; Suitor and Gleason 2002; and Stang and Bayerl 2002). At the same time, the prevalence of overweight and obesity among adolescent females has increased over time (Ogden et al. 2002), and intakes of fat and saturated fat exceed levels recommended by the Dietary Guidelines (Life Sciences Research Office 1995; Munoz et al. 1997; Troiano et al. 2000; and Gleason and Suitor 2001). Adolescent females also are more likely to skip breakfast (Devaney and Stuart 1998; and Gleason and Suitor 2001).

Older Adults. Demographic trends document an increasing proportion of the population that are older Americans. The challenges that older people face in their living arrangements, as well as physical and emotional health, income, and means of transportation, can profoundly influence eating patterns, nutrient intake, and health. Diet-related health problems among older adults include obesity, hypercholesterolemia, and hypertension (Dwyer 1991).

Empirical evidence on the dietary status of older Americans suggest potential inadequacies in the intakes of calcium, magnesium, zinc, and vitamins D, B_6, and B_{12} (Munro et al. 1987; Ponza et al. 1994; Ryan et al. 1992; and Briefel et al. 2000). A substantial proportion also report skipping meals (Ryan et al. 1992).

Overweight and Obese Children, Adolescents, and Adults. Overweight and obesity are associated with a host of adverse diet-related health outcomes. In addition, analyses of data collected through the National Health, and Nutrition Examination Surveys over the past three decades document a substantial increase in the prevalence of overweight and obesity among many age and gender subgroups (Kuczmarski et al. 1994; Mei et al. 1998; Troiano 1995; Ogden

et al. 2002; and Flegal et al. 2002). Moreover, the prevalence of obesity is highest among low-income and low-education population subgroups (Drewnowski and Specter 2004).

Empirical evidence shows that the consumption of energy-dense foods is associated with lower intakes of several micronutrients (Kant 2000, 2003), suggesting that overweight subgroups may show evidence of excess energy consumption at the same time as inadequate nutrient intake. Other studies also document the association between overweight and the consumption of energy-dense foods and soft drinks (Bandini et al. 1999; St-Onge et al. 2003; and Drewnowski and Specter 2004).

Food-Insecure Individuals. Although nutrient deficiency diseases are rare in the United States, some Americans do not have adequate access to enough food all the time. Food security, defined as access by all people at all times to enough food for an active and healthy life, continues to be important in assessing the adequacy of the diets of population subgroups (Andrews et al. 2000). Recent estimates suggest that 89 percent of U.S. households were food secure in 2001, and 11 percent were food insecure sometime during the year. About 3.5 percent of all U.S. households in 2001 experienced food insecurity with hunger (Nord et al. 2004).

Food-insecure subgroups are considered at nutritional risk for reasons other than the potential for overall low energy intake. Even if overall food energy intake is low, intake of specific key nutrients may or may not be low. In addition, if the fear or risk of not having enough to eat at all times leads to the consumption of energy-dense foods, food insecurity could also lead to overconsumption and overweight.

Existing research suggests that adult and elderly women living in households that sometimes or often do not have enough to eat (food insufficient) have lower nutrient intakes than other similar women (Rose et al. 1991; and Rose and Oliveira 1997). This relationship does not appear to hold for children (Cristofar and Basiotis 1992; and Rose and Oliveira 1997). A recent

study finds that food-insufficient groups are less likely to have adequate zinc intakes but equally likely to have adequate intakes of other key nutrients (Gleason and Suitor 2001).

Low-Income Individuals. Poverty in the United States affects individuals of all ages, from all racial and ethnic groups, and from all regions of the country. Poverty puts individuals at risk for virtually all chronic diseases. Among the dietary concerns associated with low household income are some nutrient deficiencies, dietary excesses and imbalances, increased prevalence of overweight and obesity, and poor diet quality.

Despite overwhelming evidence documenting health disparities by income, including nutrition-related health disparities, evidence on the relationship between household income and nutrient intake levels is mixed, and that relationship has varied considerably over time (Adrian and Daniel 1976; Basiotis et al. 1983; Johnson et al. 1994; and Gleason and Suitor 2001). The third Nutrition Monitoring Report in the United States concludes that low-income adolescents and adults have lower mean intakes of the vitamins and minerals considered to be of public health concern—vitamin A, vitamin C, vitamin B_6, folate, calcium, iron, and zinc (Life Sciences Research Office 1995). In addition, tables prepared from tabulations from the 1994-1996 Continuing Survey of Food Intakes by Individuals show that the percentage of individuals with average intakes less than various cutoff levels decreases with income for some, but not all, nutrients (U.S. Department of Agriculture 1999).

Participants in USDA Food and Nutrition Assistance Programs. In the past four decades, a safety net of food and nutrition assistance programs has been created to help low-income individuals obtain nutritious diets. The largest of these programs are the Food Stamp Program (FSP), the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), the National School Lunch Program (NSLP), and the School Breakfast Program (SBP). Together, these programs affect the daily food consumption of millions of Americans.

A large body of literature exists on the dietary effects of food and nutrition assistance programs. Although the effects of these programs on nutrient intake vary by program, age, and over time, empirical evidence suggests a relationship between program participation and nutrient intakes (Basiotis et al. 1987; Gordon et al. 1995; Rossi 1998; Oliviera et al. 2000; Gleason and Suitor 2003; and Fox et al. 2004). Food and nutrition assistance programs also appear to mediate the effects of other risk factors for poor dietary outcomes. For example, results from one study indicates that girls 5 to 12 years of age from households with food insecurity are less likely to be at risk of obesity-related health problems if they participate in the FSP, NSLP, and SBP (Jones et al. 2003). However, concerns about the fat content of school meals and the increasing prevalence of overweight and obesity among low-income children have caused some to ask whether the food and nutrition assistance programs are meeting the nutritional needs of low-income individuals and school-age children (Besharov and Germanis 2001).

Summary. A large body of literature suggests that several population subgroups are at risk of inadequate or excessive nutrient intake levels. However, much of this literature is dated; many of the studies use old data sets and (even for the most recent analyses) inappropriate methods to assess nutrient adequacy. In particular, while the existing literature typically focuses on a comparison of mean nutrient intake levels across population subgroups, conclusions about the nutrient adequacy of diets (prevalence of either inadequate or excessive intake levels) cannot be based on mean intake levels. This report uses data from the 1994-1996 and 1998 Continuing Survey of Food Intakes by Individuals (CSFII) and methods proposed by the Institute of Medicine to update our knowledge of the nutrient adequacy of the diets of vulnerable population subgroups.

B. STUDY OVERVIEW

Despite a host of empirical studies analyzing the dietary status of the U.S. population and various subgroups, several factors suggest the need for updated research on the dietary status of vulnerable subgroups. First, over the past decade, knowledge of nutrient requirements has increased significantly, resulting in a set of new dietary reference standards called the Dietary Reference Intakes (DRIs) (Institute of Medicine 1997, 1998, 2000b, 2001, 2002). The DRIs replace the 1989 Recommended Dietary Allowances (RDAs) and are the appropriate standards to use in determining whether diets are nutritionally adequate without being excessive. The DRIs differ from the 1989 RDAs in several respects: (1) they are based on a reduction in the risk of chronic disease, rather than merely the absence of signs of deficiency; (2) when data are available, tolerable upper intake levels are established to avoid the risk of adverse effects from excess consumption; and (3) when data are available, reference values are provided for other non-nutrient food components.

Second, studies that assess nutrient adequacy of diets have typically compared mean intake levels to the RDAs. The RDAs, however, are not the appropriate standard for assessing nutrient adequacy of diets. In addition, mean intake levels should not be used to assess either the prevalence of inadequate intake levels or the risk of excessive intake levels (Institute of Medicine 2000a).

A third reason motivating this analysis is the importance of learning more about the variation in individual intake. Individuals vary considerably in the amount of food they eat from day to day; yet it is their usual intakes—not their intakes on a given day—that determine whether their diet is nutritionally adequate. As a result, dietary assessment studies should focus on the usual nutrient intakes of subgroups. An unexplored and interesting question, however, is how

the day-to-day variation in individual intake varies across population subgroups.[1] For example, adolescent females—especially those at risk of eating disorders, such as binge eating or dieting—may exhibit greater day-to-day variation in their diets. Or it is possible that individuals living in food-insecure households may have much less variety in their diets, resulting in less day-to-day variation in intake levels. Recent research suggests that, even controlling for energy intakes, diet variety is related to aggregate measures of nutrient adequacy (Murphy et al. 2004).

1. Data Sources

The primary data set used in this analysis is the 1994-1996 and 1998 Continuing Survey of Food Intakes by Individuals (CSFII). The 1994-1996 CSFII provides information on food and nutrient intake over two non-consecutive days for 16,103 individuals of all ages and gender, and of a variety of income levels, racial and ethnic groups, and sociodemographic characteristics. The survey, conducted over three years, was designed so that the information collected on any one year would constitute a nationally representative sample of individuals of all ages. The samples were selected using stratified, clustered multi-stage sampling procedures, with an oversampling of low-income individuals. Food intake data were collected using 24-hour dietary recall questionnaires, which included information on the type and amounts of all foods consumed by individuals over two non-consecutive days. In addition, sociodemographic information, including income and participation in food assistance programs, is provided by the survey.

The 1998 Supplemental Children's Survey was designed to be a one-time supplement to the 1994-1996 CSFII, using the same design and survey methodology of the CSFII. Dietary intake data were collected from 5,559 infants and children aged 0 through 9 years over two non-

[1] As discussed above, the methods and results from the analysis of the day-to-day variation in nutrient intake are the focus of a companion report (Carriquiry et al. 2004).

consecutive days between November 1997 and October 1998. The sample was designed to be a stand-alone, nationally representative sample of children in that age range; also, however, it could be combined with the dietary information collected for infants and children up to nine years of age in the 1994-1996 CSFII. Combining the data from the Supplemental Children's Survey sample and the 1994-96 CSFII sample of children in the same age range (4,253 children) provides a large sample of children birth through age 9. This large sample of children is particularly useful in this study, since one of the high-risk subgroups is that of overweight and obese children.

One disadvantage of the CSFII is that it does not collect information on supplement intakes. The National Health and Nutrition Examination Survey (NHANES), however, does collect some information on supplement use. Using complex, multi-stage stratified clustered samples of the civilian, non-institutionalized population aged two months and older, NHANES III includes both a 24-hour dietary recall and a food frequency-like questionnaire to elicit from respondents information on the consumption of a large variety of vitamin, mineral, and herbal supplements, including usual dosage and brands. While the supplement intake data do not permit estimation of the day-to-day variability in intakes of nutrients from supplement sources (as individuals provided only a self-assessment of "usual" supplement intake), they can still be used, with some caution, to obtain an adjusted distribution of nutrient intakes from all sources.

NHANES III includes a second recall day for only a small subsample of the original sample. Of those who completed a 24-hour recall questionnaire during the first-day interview, a small self-selected sample equal to approximately 5 percent of the original sample received a second 24-hour recall questionnaire, on a non-consecutive day. The replicate sample, though small and non-random, permits estimation of the usual nutrient intake distributions using the methods proposed by the National Research Council (1986) or by Nusser et al. (1996). However, because

of small samples for the replicate observations, NHANES III does not allow a full analysis of the subgroups defined and analyzed for this study. For a few subgroups, though, NHANES III data (intakes from foods, beverages, and supplements) are used to determine whether the analysis findings from the NHANES data differ from those based on CSFII data (intakes from foods and beverages, excluding supplements).

2. Analysis Subgroups

Table 1 lists the subgroups analyzed and the unweighted sample sizes for each subgroup. Nine subgroups are the focus of the analysis:

- ***Adolescent females*:** Female individuals ages 14 to 18 years, excluding pregnant or lactating females
- ***Older adults*:** Individuals age 60 and older
- ***Individuals at risk of overweight*:** Individuals ages 20 and under with Body Mass Index (BMI) greater than or equal to the 85th percentile of national standards and individuals age 20 and older with BMI greater than or equal to 25
- ***Individuals in food-insufficient households*:** Because data on food insecurity are not available from the CSFII data, this high-risk category was defined as individuals living in food-insufficient households. Households that reported (1) "enough of the kinds of food we want to eat" or (2) "enough but not always the kinds of food we want to eat" were defined as food sufficient. Households that reported (3) "sometimes not enough to eat" or (4) "often not enough to eat" were defined as food insufficient.
- ***Individuals in low-income households*:** Individuals in households with income less than or equal to 185 percent of the federal poverty level (FPL).
- ***FSP participants*:** Individuals in households who participated in the FSP.
- ***WIC participants*:** Children under 4 who participated in the Special Supplemental Nutrition Program for Women, Infants, and Children.[2]

[2] Because the DRIs differ for children 1 to 3 years of age and children 4 to 8 years of age, the WIC analysis focuses on children 1 to 3 years of age, even though children 4 years of age are eligible for WIC.

TABLE 1
Analysis Subgroups

High-Risk Subgroup	Sample Size	Comparison Group	Sample Size
Adolescent Females			
14 to 18 years	449	na	na
Older Adults			
Males 60 to 70 years	914	na	na
Males 71 years and over	722	na	na
Females 60 to 70 years	844	na	na
Females 71 years and over	670	na	na
Risk of Overweight		**Nonoverweight**	
Kids 4 to 8 years	1,407	Kids 4 to 8 years	1,819
Kids 9 to 13 years	328	Kids 9 to 13 years	775
Males 14 to 18 years	114	Males 14 to 18 years	352
Males 19 to 30 years	411	Males 19 to 30 years	500
Males 31 to 50 years	1,167	Males 31 to 50 years	620
Males 51 to 70 years	1,131	Males 51 to 70 years	534
Males 71 years and over	357	Males 71 years and over	356
Females 14 to18 years	100	Females 14 to18 years	341
Females 19 to 30 years	290	Females 19 to 30 years	561
Females 31 to 50 years	792	Females 31 to 50 years	874
Females 51 to 70 years	904	Females 51 to 70 years	645
Females 71 years and over	324	Females 71 years and over	325
From Food Insufficient Households		**From Food Sufficient Households**	
Kids 4 to 13 years	173	Kids 4 to 13 years	4,949
Males 14 to 30 years	58	Males 14 to 30 years	1,317
Males 31 to 50 years	56	Males 31 to 50 years	1,741
Males 51 years and over	25	Males 51 years and over	2,361
Females 14 to 30 years	43	Females 14 to 30 years	1,286
Females 31 to 50 years	50	Females 31 to 50 years	1,674
Females 51 years and over	25	Females 51 years and over	2,222
Income below 185% FPL		**Income above 185% FPL**	
Kids 4 to 8 years	1,906	Kids 4 to 8 years	2,029
Kids 9 to 13 years	496	Kids 9 to 13 years	705
Males 14 to 18 years	188	Males 14 to 18 years	286
Males 19 to 30 years	366	Males 19 to 30 years	554
Males 31 to 50 years	523	Males 31 to 50 years	1,283
Males 51 to 70 years	488	Males 51 to 70 years	1,192
Males 71 years and over	309	Males 71 years and over	413
Female 14 to 18 years	181	Female 14 to 18 years	274
Females 19 to 30 years	378	Females 19 to 30 years	504
Females 31 to 50 years	559	Females 31 to 50 years	1,175
Females 51 to 70 years	548	Females 51 to 70 years	1,057
Females 71 years and over	346	Females 71 years and over	324

Table 1 *(continued)*

High-Risk Subgroup	Sample Size	Comparison Group	Sample Size
FSP participants		**Income-eligible FSP nonparticipants**	
Kids 4 to 8 years	745	Kids 4 to 8 years	706
Kids 9 to 13 years	187	Kids 9 to 13 years	158
Males 14 to 18 years	77	Males 14 to 18 years	66
Males 19 to 30 years	67	Males 19 to 30 years	188
Males 31 to 50 years	139	Males 31 to 50 years	226
Males 51 years and over	142	Males 51 years and over	389
Female 14 to 18 years	65	Female 14 to 18 years	68
Females 19 to 30 years	130	Females 19 to 30 years	179
Females 31 to 50 years	209	Females 31 to 50 years	198
Females 51 years and over	174	Females 51 years and over	426
WIC participants		**Income-eligible WIC nonparticipants**	
Kids under 1 year	618	Kids under 1 year	270
Kids 1 to 3 years[a]	883	Kids 1 to 3 years[a]	1,113
NSLP participants[b]		**NSLP nonparticipants**	
Kids 4 to 8 years	854	Kids 4 to 8 years	682
Kids 9 to 13 years	666	Kids 9 to 13 years	458
Males 14 to 18 years	212	Males 14 to 18 years	149
Females 14 to 18 years	163	Females 14 to 18 years	168
SBP participants[b]		**SBP nonparticipants**	
Kids 4 to 8 years	355	Kids 4 to 8 years	727
Kids 9 to 13 years	204	Kids 9 to 13 years	556
Males 14 to 18 years	40	Males 14 to 18 years	169
Females 14 to 18 years	20	Females 14 to 18 years	179

Source: 1994-1996 and 1998 Continuing Survey of Food Intakes by Individuals.

Note: FPL=federal poverty level; FSP=Food Stamp Program; WIC=Special Supplemental Nutrition Program for Women, Infants and Children; NSLP=National School Lunch Program; SBP=School Breakfast Program.

na = not applicable.

[a]Because the DRIs differ for children 1 to 3 years of age and children 4 years of age, this subgroup includes children 1 to 3 years of age only.

[b]Defined as usually participating 5 days per week.

- ***NSLP participants*:** Children and adolescents who reported that they usually participated in the NSLP five times per week
- ***SBP participants*:** Children and adolescents who reported that they usually participated in the SBP five times per week

For some of these subgroups, comparison groups also are examined: non-overweight individuals, individuals in food-sufficient households, higher-income individuals, and income-eligible nonparticipants. In addition, all subgroups are subdivided into age and gender groupings that typically correspond to the DRI age/gender groupings, resulting in 107 analysis subgroups.

3. Nutrients Examined

Because of the large number of high-risk subgroups and their comparison counterparts included in the analysis, it is necessary to focus the nutrient assessment on those nutrients and dietary components of public health significance. The following nutrients are the focus of the analysis and conducted in this report.

Nutrients Included in the Dietary Assessment

Micronutrients	
Vitamin C	Vitamin E
Folate	Calcium
Magnesium	Vitamin A
Iron	Zinc
Vitamin B_{12} (older adults only)	
Macronutrients and Other Dietary Components	
Food energy	Percent of food energy from
Carbohydrate	Fat
Protein	Carbohydrate
Fiber	Protein